§14. Initial Results of CUSPDEC Applied to the GAMMA 10 Tandem Mirror

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The cusp-type direct energy converter (CUSPDEC) is a device to recover kinetic energies of thermal ions produced in a D-^{3}He fusion reactor. It utilizes a cusp magnetic field to separate ions from electrons, and a dc-biased plane collector to decelerate and collect ions as a one-stage direct energy converter. A small scale CUSPDEC device, called the Kobe_Cusp DEC, was constructed and its characteristics have been investigated by using a low-energy plasma source. The CUSPDEC device consists of a plasma source, a guide field section, a cusp magnetic field section, and electron and ion collectors. The cusp field is created by two magnetic coils, A and B. By adjusting the current in the two coils, I_A and I_B, the field line curvature can be varied. Typical values are I_A = 30 A and I_B = 40 A. The Experimental results have revealed that the slanted cusp field has better capability of the charge separation than the normal cusp field. It is also found that the efficiency of energy conversion depends on the shape of the energy distribution function of incoming ions. Based on these experimental findings as well as theoretical and numerical studies, we now study the capability of the charge separation and ion energy conversion in the CUSPDEC device using GAMMA 10 plasmas as a source input.

Figure 1 shows the schematic diagram of the CUSPDEC device connected to the one end of the GAMMA

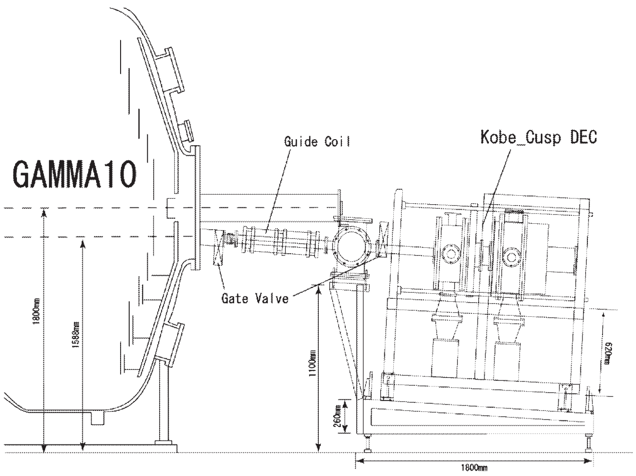

Fig. 1. Schematic diagram of CUSPDEC experimental device with GAMMA 10.

10 device through a guide section. The end loss flux of the GAMMA 10 plasma is introduced to the CUSPDEC. The data from an end loss analyzer show that the electron energy for the hot ion mode is up to 0.2 keV and that for the ECH phase is ~ 0.4 keV or higher. The parallel ion temperature is 0.3~0.5 keV. When the end loss flux is introduced to the CUSPDEC device, it is expected that electrons are deflected toward the line cusp region along the field lines and ions pass through the null point flowing into the point cusp region. We define the transmission ratio of electrons as the ratio of the electron flux at the point cusp with the cusp field to that without the cusp field. Figure 2 shows the transmission ratio as a function of I_B during the ECH phase. When the cusp field is formed (I_B > 10 A), the electron flux tends to flow into the line cusp resulting in smaller transmission ratios. The larger the value of I_B, the smaller the transmission ratio. It means that the larger slant of the cusp fields leads to the better separation.

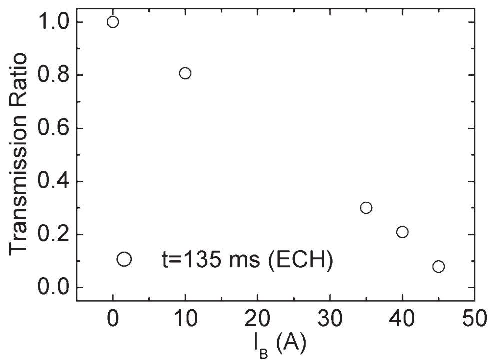

Fig. 2. Measured transmission ratio of electrons during the ECH phase with I_A = 40 A.

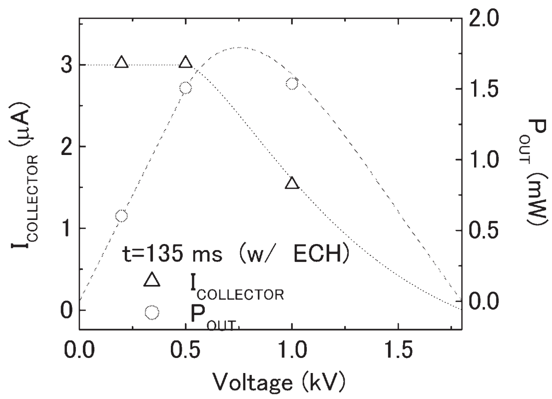

Fig. 3. Measured current-voltage characteristics of the ion collector (triangles) and estimated dc power output (circles).

The curve with triangles in Fig. 3 is the current-voltage characteristics of the ion collector operating as the one-stage direct energy converter, which is located at the point cusp region of the CUSPDEC device. The dotted line is drawn by assuming that the energy distribution function of ions is a shifted Maxwellian. The curve with circles shows the output dc power P_{OUT} available for an external load. Thus we have demonstrated that the basic functions of the CUSPDEC device are well operative for plasmas of the existing open magnetic confinement system.